World Quests for Future Energy Production

José A. Orosa, Enrique J. García-Bustelo, Teresa Grueiro
Department of Energy and M.P. University of A Coruña.
Coruña, Spain
jaorosa@udc.es

***Abstract*-In the past years, there were a lot of initiatives from different countries to propose improvements in nuclear and wind energy. These improvements were regarding treatment of waste materials, studies, common development and the development of standards for different countries, and new research process in the designing of new nuclear reactors and alternatives energy sources. All these parameters will be analysed in this paper with special attention to the past research works developed in the recent years.**

Keywords-World, quest, nuclear, alternative, energy, future.

I. INTRODUCTION

In nuclear energy proliferation, an accident at a particular place is likely to impact the whole world; this effect is enhanced with the rise in terrorist activities and with the problem associated with waste disposal. In 2008 interest in nuclear power was aroused all over the world as it was considered as a possible solution for global warming and the security of energy supplies. This interest was mainly because public opinion toward nuclear energy had changed from negative to positive in many countries and, in consequence, governments were reviewing their nuclear policies. As a consequence, there has been a clear increment in research and development efforts in advanced nuclear power plants. For this development to take place, three things are required: action by countries, action by industries in research and development, and international initiatives [1]. These three points of view will be analyzed in this paper.

In 2009, in accordance with the International Atomic Energy Agency about 52 countries showed interest in constructing their first nuclear power plant [2]. For example, India's energy sector is based on fossil fuels and, with an aim to reduce global warming and climate change, a substitution of fossil fuels by nuclear energy is expected. By the year 2045 more than 50% of the Indian energy market will be from nuclear energy. More research works [3, 4] revealed the same problematic situation in Turkey and China, where most of the energy is produced from fossil fuels and its legislation is changing towers incentive the development of nuclear power plants due to the existence of energy security problems and the use of nuclear energy in a near future is inevitable. Due to this, it is not possible for all these countries to implement these changes within a short time. There are some indicators about the potential of nuclear energy in a country like, for example, the presence of an international grid connection, the security of fuel supply for electricity production, and politically stable economies [2].

In the past years, the effect of nuclear energy over the economy of countries was analyzed. For example, the Korean national economy was analyzed and its main results were centered on three topics, namely, the impact of nuclear power supply investment on the production of other sectors and the inter-industry linkage effect, shortage of nuclear power supply, and the impact of the rise in nuclear power rate on the prices of other products [5]. Further research works [6, 7] have analyzed the relationship between nuclear energy and oil prices from 1971 to 2006. Results from such works have shown that the effect of nuclear energy over a country's economy will be evident only in the long run, suggesting the substitution of oil by nuclear energy. Therefore, no obvious impact was noted within a short span of time. The same research group showed that in some countries like the USA and Canada, nuclear energy would substitute the oil resources while in other countries like France, Japan and the United Kingdom they were complimentary [8]. Further research works showed the relationship between energy consumption in real gross domestic products (GDP) for nine developed countries [9] and results showed that in some countries like Spain, USA, and the United Kingdom, an increase in nuclear energy increased the economic growth. On the other hand, the opposite was true in countries like France, Japan, and Netherlands.

Despite this, economy is not the only parameter to be considered to assess the impact of nuclear proliferation in a country. For example, by using quantative models the approach is based on more parameters like security environment, political development, nuclear technology capability, and a commitment to nuclear proliferation of 189 countries. Another procedure to reach the same objective is the historical analysis of events based on the Weibull model which seems to be the most reliable modelling approach to project a nuclear proliferation decision [10].

Finally, from these studies it was noted that significant variables that affect a country's proliferation decision are in accordance with political theories like, for example, industrial capacity index, economic openness, economy liberation, and gross domestic products (GDP) per capita. Furthermore, a country's capability for nuclear technology and commitment to nonproliferation are important in defining its nuclear proliferation behavior [10].

As commented earlier, the main advantages of nuclear energy in the USA were demonstrated by means of the dose risk analyses. Besides these advantages, we can find that nuclear energy can reduce air pollution and the lifecycle greenhouse gas emissions when compared to fossil fuels. Furthermore, employing nuclear energy reduces reliance on natural gas-fired electric plants and the development and use of electrical vehicles based on hydrogen and other portable fuels [11]. Despite this, nuclear energy is not the only future energy source and it must be considered along with another renewable

energies. For example, when the subsidization of the nuclear industry was compared with providing this same sponsor to manufacture photovoltaic modules, it was shown that it would result in more energy over the lifecycle of the technologies [12].

II. Renewable Energies as Decentralized Technologies in Rural Areas

In recent research works, it was shown that decentralized energy technologies based on the availability of local resources can be a viable alternative to rural electrification through the extension of the main grid. It is the case of India [13]. Most of the decentralized plants are based on wind power, hydroelectricity, and biomass gasification. At the village level, the decentralized planning approach has been attempted on a small scale for isolated projects that meet limited energy needs.

Another recent research [14] investigated how rural electrification could be achieved in India using different sources of energy and the effects that it would have on the steps toward climate change mitigation. With this aim, the electrification options for rural nonelectrified households in India were modelled, and the impacts of the four different types of electrification were assessed: central grid–based, using electric appliances; decentralized diesel-based, using electric appliances; decentralized renewable energy–based, using electric appliances; and decentralized renewable energy–based, using mainly renewable energy–based appliances. The results of the above study showed that rural electrification with renewable energy could reduce up to 90% of the total CO_2 emissions originating from the residential sector, compared to electrification with grid and diesel systems, and therefore have very high climate change–mitigation potentials. It is also expected that renewable energy–based electrification could also reduce use of primary energy, compared to electrification with grid and diesel systems, and thereby save energy resources.

Similarly, research on adaptation of wind turbines for remote and stand-alone applications is receiving increasingly greater attention. For example, hybrid power systems using 1–50 kW wind turbines are being developed for generating electricity in the grid and, in many parts of India, for grid connections. In the latter case, distributed energy resources, such as small wind systems ranging from 50 to 300 kW, provide energy for village electrification, water pumping, battery charging, use by small industries, and so on. In India, however, the use of wind as an energy source for decentralized energy generation is at a preliminary stage [13].

One of the principal decentralized applications is the pumping of water from groundwater for irrigation. There were reportedly more than 15 million electricity-driven pumps and 6 million diesel pumps in operation in the agriculture sector in the year 2003. Under this situation, diesel is expected to become increasingly expensive and scarce and, in consequence, a substantial potential for using renewable sources of energy for pumping of irrigation water is expected. In India, the options of renewable energy for water pumping include solar photovoltaic pumps, windmill pumps, and dual partial substitute for diesel [15]. When the photovoltaic pump system was analyzed, it was concluded that the power obtained from this system in the field is generally less than the rated power. It is due to reasons such as decreases in the efficiency of a solar cell when temperature increases, solar irradiance lower than 1 kW/m2, and the high downtime required for repair and maintenance.

However, when the use of the windmill pump was analyzed [15], it was noted that the total number of windmill pumps installed was far below their estimated potential of 0.4 million. One of the main barriers against the large-scale adoption of windmills is the financial viability, because the annual useful energy delivered by a water-pumping windmill depends on the wind-power availability feasibility in a region and the corresponding problems related to wind-energy conversion, which are discussed below.

III. Problems of Nuclear and Renewable Energies

A. *Problems of nuclear energy*

To obtain new and more effective transformation of nuclear energy in collaboration with renewable energy, more research activities must be developed. In this context, a really technical progress in the nuclear industry is considered to be slow compared to other traditional sciences. In consequence, there is a strong need to review the educational requirements for undergraduate and postgraduate studies to provide applied engineering skills required to design, built, and operate nuclear systems and to develop new technologies that ensure energy supply in accordance with a common world standard.

The first example of cooperative activities in new nuclear education like M.Sc. Level Nuclear Science and Technology education, improvement of curriculum, and infrastructures of undergraduate nuclear study programs was between Japan and Indonesia [16].

At the same time, improvement in education has implied an increment in technology [17] related to safety in nuclear energy production, waste management, and storage. These waste materials are treated using three different, short-term, methods, namely vitrification, ion exchange, and employment of Synroc; long-term methods such as storage, geological disposal, transmutation or reuse of waste, and space disposal can also be carried out. Further research on this topic is required.

B. *Problems of wind-energy conversion*

The electricity generated by wind is still more expensive than power obtained from conventional power plants, unless the environmental benefits of wind power are taken into account. If the cost of wind energy could be reduced by an additional 30–50%, then it would be globally competitive. The goal of achieving this reduction has inspired designers to seek cost reduction by increasing the size, tailoring of turbines for specific sites, exploring new structural dynamic concepts, developing custom generators, and power electronics, in addition to implementing modern control-system strategies [18]. It was concluded that to improve wind energy conversion, the principal design factors that must be analyzed are the power in the wind, the load factor, wind turbine–axis orientation, the area required, and the grid connection. The power in the wind depends on the wind statistics, the seasonal

and diurnal variations of wind power, and variation with time. In particular, when the wind blows strongly (speeds more than 12 m/s), there is no shortage of power, and often, the generated power has to be dumped. Difficulties appear if there are extended periods of low- or zero-speed winds. The load factor is not a major concern when the wind electric generator acts as a fuel-saver on the electric network; nevertheless, if the generator is pumping irrigation water, for example, in an asynchronous mode, the load is very important.

To select between different orientations of the axis, according to the orientation of turbines, HAWTs and VAWTs can be considered. The principal advantages of VAWTs over conventional HAWTs are that VAWTs are omnidirectional and, in consequence, they accept the wind from any direction. This simplifies their design and eliminates the problem imposed by gyroscopic forces on the rotor of conventional machines as the turbines yaw into the wind. The vertical axis of rotation also permits mounting the generator and gear at the ground level. On the negative side, VAWT requires guy wires attached to the top for support, which may limit its applications, particularly for offshore sites.

The area of land required depends on the size of the wind farm, and the optimum spacing in a row is 8–12 times the rotor diameter in the wind direction and 1.5–3 times the rotor diameter in crosswind directions.

The last parameter is related to the grid connections. For the economic exploitation of wind energy, a reliable grid is as important as the availability of strong winds. The loss of generation for want of a stable grid can be 10–20%, and this deficiency may perhaps be the main reason for the low actual energy output of wind mills compared to the predicted value [18]. Consequently, this is one of the most important factors that must be corrected in future wind energy–converter designs.

IV. FUTURE WORKS

A. *Future works in nuclear energy conversion*

USA and Japan have published regarding the development of advanced battery technology to be applied to plug-in hybrid electric vehicles [19] and regarding interests in the substitution of the fossil fuel electricity by nuclear electricity to improve the energy security in power supply. To reach this objective, three different nuclear reactors called light water reactors, sodium-cooled gas reactor, and very high gas-cooler reactor were examined. Furthermore, new research works regarding new reactor designs like adiabatic core reactor and hybrid reactor are being investigated. In particular, the so-called adiabatic core concept [20] is an interesting solution that allows in maintaining a constant total amount of guilt onion and minor actinides, consuming only uranium and discharging to the environment only fission products and reprocessing losses. On the other hand, recently, the hybrid reactor has been analyzed [21], showing its main advantages.

In 2010 new proposals of standards were shown for a near future with a need for nuclear energy production [22]. Envisaging the elaboration of a European standard review plan that could be considered suitable for use by all nuclear safety regulators may be too optimistic as there is little in common in the works between vendors, utilities, and regulators [22].

B. *Future proposals for wind-energy conversion*

Wind-power technology is experiencing a major growth, especially in the United States and Europe, and a significant growth has been observed in developing countries such as China and India. As a result of scientific assessments of wind resources throughout India, wind power has emerged as a viable and cost-effective option for power generation [23]. Thus, the wind-power potential in India has been assessed at 45,000 MW, with 1% land required for wind-power generation in potential areas. Assuming a capacity utilization factor of 25%, the identified potential can generate electricity equivalent to approximately 100 TWh per annum [13]. On the basis of the growth trends, the predictions about the future of wind energy in India showed that 99% of India's technical wind-energy potential may be achieved by the year 2030 [23]. Furthermore, it has been assumed that with better resource assessment and further increase in conversion efficiencies, the identified potential can generate approximately 117 TWh by 2051–2052 [13]. To accomplish these improvements, the MNES, Indian Renewable Energy Development Agency, and the wind industry are working together through various R&D programs. For example, Herbert et al. [24] reviewed the models used for wind-resource assessment, site selection, and aerodynamics, including an analysis of the wake effect. They concluded that with reference to the site selection, the coastal and dry arid zones have good wind potential, and the winds blowing during the period from November to March are relatively weak in India. Of the five potential Indian states, Maharashtra and Karnataka show a relatively steep increase compared with other states [25]. When the aerodynamic models were analyzed, it was observed that both the horizontal-axis wind turbine (HAWT) and vertical-axis wind turbine (VAWT) design are very efficient; however, both are being rigorously tested and improved until date [24]. In spite of these developments, wind speeds less than 5 m/s are not of much relevance to wind-energy applications. Chikkodi, Horti, Kahanderayanahalli, Kamkarhatti, Raichur, and Bidar have wind velocities greater than 5 m/s for most of the months of the year; the wind-energy potential is high in these locations and, therefore, construction of wind farms is recommended at these locations [25].

Finally, although the emphasis on renewable energy in India has been growing, aggressive policies, targets, and work programs for promoting RETs are still lacking. The rural areas provide a significant opportunity to apply photovoltaic, microhydro, and biopower technologies in future years [26]. Furthermore, there is a need for targeted technology development and research and development (R&D) for cost reduction–low wind–speed machines, inverters, and controllers of a few kW—for reduction of the manufacturing cost of photovoltaic modules.

The principal parameters analyzed above are related to the cost of wind energy and, hence, with the financial viability; these factors are now considered for a proposal for the future. As shown before, India portrays the need for a renewable energy conversion in decentralized areas, where the principal problem is the instability in wind velocity, which in turn increases the cost of wind energy.

In previous research works, Shikha proposed a wind concentrator for this same problematic situation [27, 28]. This

same concept was further analyzed [29, 30], and its energy conversion was improved based on the phase change of moist air. This recent implementation is based on the Foehn effect and consists of a nozzle, a rotor, and a diffuser designed to get the maximum mechanical energy from the free stream of airflow [31]. Finally, a Savonius rotor was proposed [32] for low wind–speed areas.

Finally, in recent research works, the combined effect of two wind farms was simulated; one with and another without wind concentrators [33]. Results showed major energy-conversion stability under different ranges of wind speed. Furthermore, other applications of this system, such as controlling the velocity of wind turbines with the relative humidity of moist air, are suggested.

V. CONCLUSIONS

The change from classic fossil fuel to nuclear energy as energy resource for countries is imminent in the long run due to its reduction in global warming, climate change, and improvement in energy security. All these advantages will improve a country's economy in the long run. Despite this, nuclear energy must be developed in conjunction with renewable energies and collaborative actions must be taken between countries to define common standards for nuclear energy. Finally, research and development must be improved with more adequate studies and research works about nuclear energy production, waste management, and storage.

The current India centralized energy planning model ignores the energy needs of rural and poor areas and has also led to environmental degradation, whereas the decentralized energy planning model is in the interest of efficient utilization of resources. It is found that small-scale power-generation systems based on renewable energy sources are more efficient and cost effective. Thus, the focus should be on small-scale RETs that can be implemented locally by communities and small-scale producers, but which can make a significant overall contribution toward the national energy supply. Although India has made considerable progress in implementing technologies based on renewable sources of energy, the decentralized energy–technology applications are still few [13]. It was found that rural electrification with renewable energy could reduce up to 90% of total CO_2 emissions; therefore, these options have very high climate change–mitigation potentials and could also reduce primary energy use, compared to electrification with grid and diesel systems, and thereby save energy resources [14].

Renewable energy needs to gain the confidence of developers, customers, planners, and financiers. This can be established by renewable energy establishing a strong track record, performing to expectations, and improving its competitive position relative to conventional fuels. In this sense, the barrier in renewable energy development and penetration is, with reference to wind power, the tapping of wind potential, which is difficult due to the wide dispersal of wind resources.

Finally, although the emphasis on renewable energy in India has been growing, aggressive policies, targets, and work programs are still lacking. There is a need for targeted technology development and R&D for cost reduction.

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